MICROMOUSR

ECE 445 - Team 77
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Introduction

- An innovative startup device.
- A robot cat toy to entertain pets and owners alike.
- Voted Best Cat Toy 2018.
Mouss in Action
Objectives for MicroMousr

1. Sensor components must exist on one board and be capable of fitting in the physical body of the Mousr product (3.4 x 2.2 x 1.4 inches).
2. Must be able to demonstrate basic movements and control while in Autonomous Mode, and respond to user control when in Manual mode.
3. Electronic components must cost less than the current Mousr model.
MicroMousr System
High Level Design
Power

- Power is stored in a 4.2 V battery
- Charging circuit includes reverse voltage protection
- Distributed through two LDO voltage regulators
  - Main components and sensors
- Provides for separate ON and OFF modes
Power Distribution Network

Charging Circuit

USB Power Input

Battery Connection

Regulator to Processor

Regulator to Sensors
LDO

Enable

Power from Battery

Enable

Output to Sensors

Output to Main
LDO Response Time
## Power Consumption

<table>
<thead>
<tr>
<th>Load</th>
<th>Voltage (Typical)</th>
<th>Voltage Range</th>
<th>Current (Active)</th>
<th>Current (OFF / SLEEP)</th>
<th>Power Consumption (Active)</th>
<th>Power Consumption (OFF / SLEEP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processor</td>
<td>3.0</td>
<td>1.7-3.9</td>
<td>5.4mA</td>
<td>.7µA</td>
<td>16.2mW</td>
<td>.0021mW</td>
</tr>
<tr>
<td>ToF</td>
<td>+2.8V</td>
<td>2.6V-3.5V</td>
<td>19mA</td>
<td>0A</td>
<td>20mW</td>
<td>0W</td>
</tr>
<tr>
<td>IMU</td>
<td>1.8V</td>
<td>1.71V-3.6V</td>
<td>.45mA</td>
<td>0A</td>
<td>0.81mW</td>
<td>0W</td>
</tr>
<tr>
<td>Motor Driver</td>
<td></td>
<td>[Reference Calculation 2]</td>
<td></td>
<td></td>
<td>769.2mW</td>
<td>0W</td>
</tr>
<tr>
<td>LED</td>
<td>2V</td>
<td>2V-5V</td>
<td>20mA</td>
<td>0A</td>
<td>75mW</td>
<td>0W</td>
</tr>
<tr>
<td>Push Button</td>
<td>3V</td>
<td>1V-24V</td>
<td>15µA</td>
<td>15µA</td>
<td>.045mW</td>
<td>.045mW</td>
</tr>
<tr>
<td>Voltage Regulator (x2)</td>
<td>4.2V</td>
<td>2.1V-6V</td>
<td>40µA</td>
<td>0A</td>
<td>.168mW</td>
<td>0W</td>
</tr>
<tr>
<td><strong>Total Power Consumption</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>821.186mW</strong></td>
<td><strong>0.05799 mW</strong></td>
</tr>
</tbody>
</table>
Microprocessor

- Cortex-M4 ARM Processor
- Bluetooth Low Energy compatibility
Microprocessor Schematic
Time of Flight

- Optical sensor that uses infrared filters to measure distance
- Used for obstacle avoidance
- Smallest ToF sensor on the market
- Extremely accurate within a 0.7 meter range
Time of Flight
Time of Flight
IMU

- Inertial Measurement Unit
- 3-Axis Accelerometer
  - Pitch, roll and yaw are rotation around X, Y and Z axis
- 3-Axis Gyroscope
  - Delivers rotation values for each axis
Push Button

- Switch between OFF and ON modes
- Debounce circuit
Push Button Debounce
RGB LED

- Signal direction of movement
- PWM Driven
Push Button and RGB
Motor Driver

- Dual H-Bridge Chip for two DC motors
- PWM signal from GPIO controls motor direction and speed
- Phase/Enable allows for bidirectional control
Hardware Design
Hardware Design

- USB Input
- Connection to Motor
- IMU
- SWD
- Connection to TOF
- RGB LED
- Microprocessor
- Connection to Motor
- Pushbutton
- Power Regulation
- Connection to Battery
- Charging circuit
- Connection to TOF
Communication

- Bluetooth connection through Petronics app

\[ \text{Throttle} \in [0, 0.4] \]

\[ \text{Angle} \in [-180, 180] \]
High Level Software

- Microprocessor ON
- System Initialization
  - Bluetooth Ping
    - Manual Mode
    - Autonomous Mode
System Initialization Procedure

- BLE Init
- Push Button Init
- TOF Init
- TOF Init?
  - Y: Motor Driver Init
  - N: High Level Controller Init
  - N: Do Nothing
  - N: Crash

- BLE Handler
- Push Button Handler
- TOF Handler
- Motor Driver Controller
- High Level Controller Loop
High Level Multithreaded System Description
ORB Message Passing Protocol

**BSPSignal**
- ButtonPressed

**rcPWM**
- r_PWM
- l_PWM
- Reverse
- Spin

**BLE_MSG_in**
- BLE_CMD_T
  - Angle
  - Throttle

**ORB Message Subscribing Protocol**
- Advertiser
  - Poll (Blocking)
  - Check & Copy (Non-Blocking)
  - Advertiser
  - Subscriber
High Level Controller Design

Flowchart:
- **High Level Controller Task**
  - BLE MSG Check&Copy?
    - **Y**
      - Enumerate on Angle
        - \(-7 \leq \text{Angle} \leq 7\)
        - \(173 \leq \text{Angle} \leq -173\)
        - \(-90 \leq \text{Angle} < -7\)
        - \(-173 < \text{Angle} < -90\)
        - \(7 < \text{Angle} \leq 90\)
        - \(90 < \text{Angle} < 173\)
    - **N**
      - RC?
        - TOF Get Data
        - Enumerate on TOF & Spin
          - TOF>3000 & Spin
          - TOF<700 & !Spin
        - Default
  - Assign rcPWM_out signal values and publish
PWM Driver Design

Guide

PWM Initialize
- Configure GPIO PWM R_MOTOR, L_MOTOR, LED
- Set GPIO PWM Event Handler

PWM Driver Task
- Poll rcPWM
- Enumerate on rcPWM
  - rcPWM_in.spin
  - rcPWM_in.reverse
  - Default
- Assign Global Variable rPWM and iPWM

PWM Event Handler
- Event = PWM_Finished?
  - N
  - Y
    - Assign PWM Channel Values for R_MOTOR, L_MOTOR, LED
Dual Motor PWM control
### Cost Summary

- **$29** at non-bulk pricing
- **$17** at bulk pricing
Conclusions and Further Work

- Autonomous control based on ToF input
- Manual control with app input from Bluetooth
- Hardware connections intact

Issues:
- Processor module clock speed
- Required libraries
- IMU integration
- Charging circuit
- Motor wires
THANK YOU
to Petronics and ECE Course Staff